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SERIES III.

1522
Nos. 1 & 2.

HOUGHTON FARM.

EXPERIMENT DEPARTMENT.



DISEASES OF PLANTS.

1882.

NORMAL CONDITION OF CELLULAR STRUCTURE AND PEACH YELLOWS,

BY

D. P. PENHALLOW, B. S.

New York:

E. S. DODGE, STEAM PRINTING HOUSE, 95 CHAMBERS STREET.

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LAWSON VALENTINE,
Proprietor.

HENRY E. ALVORD,
General Manager.

D. P. PENHALLOW,
Botanist and Chemist.

POST, TELEGRAPH AND EXPRESS OFFICES:
MOUNTAINVILLE, ORANGE CO., NEW YORK.

Visitors are always welcome at Houghton Farm.

EXPERIMENTAL WORK.

With the present report upon some of the experimental work of the past season, it seems desirable to give a brief outline of the plan upon which the work of the Experiment Department is based, so far as fully determined, and the order in which the reports will be issued.

With the spring of 1882, experiments were instituted with special reference to determining certain important questions in vegetable physiology and the special relations of meteorological and soil conditions to the normal vital processes of the plant. While the subjects presented for inquiry were naturally somewhat numerous, they were all more or less directly connected with the solution of one or two important considerations, of which the diseases of plants was the principal. To bring together all the facts observed during the year, and compile them in a manner which would permit the logical presentation of the whole subject with decisive conclusions bearing upon the main question, seemed to involve an undesirable confusion of diverse subjects. This, aside from other considerations, finally led to the plan of presenting each subject in a special paper, which should form one of a definite series. The questions are of such a nature that they are naturally grouped under the three heads of

AGRICULTURAL PHYSICS, PHENOMENA OF PLANT GROWTH, and DISEASES OF PLANTS.

These, then, form the series under which special papers will be arranged. Papers 1 and 2 of the first series were issued in February; papers 1 and 2 of the third series are contained in the present report, while papers of the second series will follow shortly. As stated in the first report, these papers will not be issued at regular intervals, but will appear from time to time as suitable material is obtained.

In this connection, it seems desirable to acknowledge the efficient services of my assistant, Mr. W. E. Stone, whose pen prepared the drawing and some of the charts in the first reports; the plates in the present reports are from my own pen. Also to acknowledge the friendly assistance received from Dr. C. A. Goessmann, Dr. Daniel Draper, Prof. S. T. Maynard, and many others.

The frequent objection made by farmers and others who receive these pamphlets, that the metric and centigrade systems do not meet their requirements, seems to make a word of explanation desirable. The requirements of scientific research at the present time, necessitate the use of uniform standards of temperature and measure which will bring observers and their work, in various parts of the world, into the greatest harmony. Again, the use of the Fahrenheit and English systems involves an inconvenience which, in the construction of charts, not infrequently seriously interferes with their production. Furthermore, the centigrade thermometer

and the metric system of measures, are the most rational of all the methods now in use for a similar purpose, and the objection that people do not understand them, is no argument against their use, it rather argues that the people should be more disposed and willing to develop a higher degree of intelligence which will enable them to comprehend the scientific methods employed. If the food is brought to one, he at least should be willing to make the necessary effort to eat it. It can hardly be expected that scientific men can be at the labor and expense of obtaining facts for general use, and that all their presentations should be in a form requiring no effort on the part of the user. To obviate any difficulty as far as possible, tables will accompany each report.

D. P. P.

HOUGHTON FARM.

EXPERIMENT DEPARTMENT.

SERIES III.—No. 1.

The Normal Condition of Vegetable Structure with
Reference to Cell Contents.

BY

D. P. PENHALLOW, B. S.

1882.

The Normal Condition of Vegetable Structure with Reference to Cell Contents.

During the progress of our studies relative to the Yellows in peaches, there appeared to be such strong variations in the amount of reserve material stored by the cells under various conditions, that it came to be a matter of considerable importance for the successful prosecution of the main question at issue, to determine carefully what relations normally exist between the reserve materials of the plant and conditions of health and disease at various seasons of the year. The microscopical examinations have been carried on during the past year, and the following facts were obtained.

In order to make the results of the greatest value, trees of widely different relationship, growing in different localities, and under conditions of cultivation as well as in the wild state, were taken without any special selection which might tend to affect the results. Care was taken, however, to select only those trees which from their age and general appearance, would, as the term is ordinarily applied, be justly termed healthy. It was necessary to assume, moreover, that all trees growing in a natural condition, and having the external appearance of health, were healthy. The determination of the normal condition of health in our trees at large, is a question which merits the most careful inquiry in the future, and in the light of such an examination, our assumption may prove fallacious in certain particulars, even though we admit its present necessity as a working hypothesis.

Another important consideration involved, was the influence of season upon the amount of reserve material which the tissues might contain at any one time. To avoid possible error in this direction, specimens were selected from the same tree in early spring before there was any growth ; during the time of active growth in June ; early in September, after the wood had formed and growth for the season was ended, but before the leaves had fallen ; and again in November, after the trees were in their winter condition of rest. The subjects selected—arranged in their natural order—were as follows :

1	<i>Vitaceæ.</i>	<i>Vitis cordifolia.</i> Michx.	Wild Grape.
2	<i>Sapindaceæ.</i>	<i>Acer saccharinum.</i> Wang.	Sugar Maple.
3	<i>Rosaceæ.</i>	<i>Amygdalus Persica.</i> L.	Peach.
		<i>Prunus domesticâ.</i> L.	Plum.
		<i>Prunus cerasus.</i> L.	Red Cherry.
		<i>Prunus serotina.</i> Ehrh.	Black Cherry.
		<i>Pyrus communis.</i> L.	Pear.
		<i>Pyrus malus.</i> L.	Apple.
4	<i>Cornaceæ.</i>	<i>Cornus florida.</i> L.	Flowering Dogwood.
		<i>Cornus sericea.</i> L.	Silky Cornel.
5	<i>Oleaceæ.</i>	<i>Fraxinus Americana.</i> L.	White Ash.
6	<i>Urticaceæ.</i>	<i>Ulmus Americana.</i> L.	Elm.
		<i>Ulmus fulva.</i> Michx.	Slippery Elm.

7	<i>Platanaceæ.</i>	<i>Platanus occidentalis.</i> L.	Buttonwood.
8	<i>Juglandaceæ.</i>	<i>Carya alba.</i> Nutt.	Hickory.
		<i>Carya porcina.</i> Nutt.	Pignut.
9	<i>Cupuliferæ.</i>	<i>Quercus rubra.</i> L.	Red Oak.
		<i>Castanea vesca.</i> Gaertn.	Chestnut.
		<i>Fagus ferruginea.</i> Ait.	Beech.
		<i>Fagus sylvatica.</i> L. Var. <i>purpurea.</i>	Purple Beech.
10	<i>Betulaceæ</i>	<i>Betula nigra.</i> L.	Black Birch.
11	<i>Salicaceæ.</i>	<i>Salix alba.</i> L. Var. <i>vitellina.</i>	Golden Willow.

Branches were taken from these trees at the proper time for collection, care being taken to secure wood of at least three years' growth. Unless the sections were to be cut at once, the specimens were cut into convenient lengths and immersed in alcohol until wanted. As the sections were to be cut, the specimens were taken directly from the alcohol and the growth of each year cut and kept separately. Each specimen was then carefully bleached, and subsequently treated, first with iodine to develop the starch reaction, and next with a proper amount of glycerine to clear up the structure and preserve it without change. Specimens treated in this manner have worked most admirably, and after one year show no change. The whole number of examinations made was 360. The facts obtained appear as follows:—

WILD GRAPE. *Vitis cordifolia.* Michx.

During the time of active growth, the youngest formation of wood shows that the pith is devoid of starch. The rays are partly filled, and a small quantity of starch is found in the liber and outer bark, the largest quantity occurring in a few cells just external to the bast. Crystals are occasionally to be seen in both the pith and bark. As the growth becomes older, the features do not change materially. The leaves show that starch is generally distributed through all their structure, but that it is most abundant in the palisade cells. As the season advances, there appears to be no change in the amount of stored material, even as late as the first of September. At this time, however, the leaves show that all the starch has been replaced by oily matter. After fall of the leaves in November, there is found to be a large accumulation of starch in all parts of the structure except the pith, which remains empty. The sheath, all the rays and wood cells, as also many of the bast cells, are completely filled with starch. The crystals in the bark show no increase. Fully one-third of the liber cells, and nearly all of the mesophlœum cells, are densely filled. Wood collected in March shows that while there is considerable starch present, it is mostly confined to the sheath and rays in the woody structure, and in the bark is largely localized in the vicinity of the bast bundles.

Older growth does not present any material differences.

SUGAR MAPLE. *Acer saccharinum.* Wang.

June. The pith is small and devoid of starch. The sheath and pith ends of the rays are well filled. Starch also occurs in some of the inner liber cells, and in a few of the mesophlœum cells just external to the bast, with scattering grains in occasional cells throughout the outer bark. As the structure grows older, the starch

extends more completely through the rays, until, in the second year and after, the mesophlœum cells all become well filled, as well as a number of the liber cells. During the first year the number of crystals is somewhat limited, but with the second year they become quite abundant. The leaves are well filled with starch throughout, though it predominates in the palisade cells.

Early September. The pith is large, but empty. The sheath and rays, as well as a few of the wood cells, are well filled with starch. In the bark, about one-eighth of liber cells and one-half of the mesophlœum cells are half filled with starch. In older growth, the characters remain the same, with a possible decrease of starch in the bark. The crystals are rather abundant and small. The leaves contain an abundance of starch, but there is an almost entire absence of oily matter.

November. The pith is empty, but the sheath, rays, and many of the wood cells are densely filled with starch, which is also occasionally found in the liber. The mesophlœum shows the starch to be scattering, only one-fourth of the cells being partly filled, while the crystals are not very abundant. In the growth of two years and older, there appears to be no perceptible difference.

March. The pith is small and empty. The starch is fairly abundant in the medullary sheath, and thence extends through the rays and a few of the wood cells to the bark, where it largely disappears. As the growth becomes older, the starch appears to increase somewhat in all parts, but chiefly in the wood, the quantity in the bark being very limited even in the oldest wood.

PEACH. *Amygdalus Persica.* L.

Healthy wood collected at various seasons of the year, shows that, while the sheath and rays contain an abundance of starch, there is little or none in the bark during the growth of the first year. Crystals are more or less abundant in the bark. As the structure becomes older, the quantity of starch increases in all parts, but not to a very marked degree in the bark. During the growing season the leaves do not contain very much starch, and only a few crystals. Later in the season, early in September, the starch is replaced by oil as the foliage ripens. Wood taken after the leaves fall, shows some increase of starch in the various parts, but not to a very marked degree. Otherwise there is no difference between this and that taken earlier in the season.*

PLUM. *Prunus domestica.* L.

Early September. In the growth of the season, the pith is empty, but the sheath, rays, and some of the wood cells are densely filled with starch. Three-fourths of the outer bark cells are well filled. The growth of two years and older, shows a strong increase in starch and an abundance of crystals. The leaves contain but little starch, which has been largely replaced by oily matter.

November. After the fall of the leaves, the wood shows the same distribution of starch observed in September, but there is evidently a larger quantity in the bark cells. The same relation of reserve material to age, seems to hold good here as in previous cases.

*For more detailed characters of the peach, see the following paper.

March. The pith is empty, but the sheath and all the rays are well filled with starch, which is almost wanting in the bark. The crystals are large and abundant. The growth of two years and older presents nothing different. An abundance of fungus was to be seen on the outer bark, but none could be found penetrating the tissues.

RED CHERRY. *Prunus cerasus*. L.

June. The pith contains no starch. The latter appears abundantly in the sheath, but sparingly in the rays. It becomes rather abundant in the liber, increasing in quantity in the outer bark. The crystals are abundant and large. In older growth, the starch appears in a few of the pith cells, densely fills the sheath, and becomes somewhat conspicuous in the rays. There is also a noticeable increase of starch in the bark. The crystals are large and abundant. All the cells of the leaves are well filled with starch, especially the palisade cells.

Early September. Occasional cells in the pith are well filled with starch. All the sheath and ray cells are well filled, as also most of the liber and all of the mesophloem cells. The crystals are abundant. In older growth the characters show no essential variation. The leaves contain but little starch, it having been replaced by oily matter.

November. Wood collected after the fall of the leaves shows that there is no change in the amount of stored starch after September. The distribution remains the same as in the previous case. The same relation of starch to age appears, however.

March. The pith contains no starch. The sheath and rays are well filled with starch, but none appears in the wood cells, or in the liber except in the terminal ray cells. In the outer bark, about one-eighth of the cells are half filled with fine grained starch. Crystals are somewhat abundant throughout the bark. In older growth there is no especial difference beyond the fact that the starch shows a somewhat general increase in all the tissues.

WILD CHERRY. *Prunus serotina*. Ehrh.

Early September. The pith is empty, but the sheath, rays, and some of the wood cells are well filled. Crystals are abundant in the bark. From one-half to two-thirds of the outer bark cells are well filled. Growth of two years and older shows the same distribution of starch with a general increase in quantity. The leaves contain a few scattering grains of starch, the greater portion of which has been replaced by oil.

November. The pith is empty, but there is an abundance of starch in the sheath, rays, and a few of the wood cells. In the bark, both crystals and starch are abundant, the latter densely filling all of the cells of the outer bark not occupied by the former. In the liber the starch is confined to the rays. Older growth of two and four years, shows that there is an increase of starch with age in the wood cells and liber.

March. All the pith cells are devoid of starch. The sheath and rays are well filled, but there is no starch in the wood cells. Both starch and crystals are present in the bark in small quantities. As the growth becomes older the starch increases, particularly in the wood and bark, in which latter it becomes abundant.

PEAR. *Pyrus communis*. L.

Growth from trees which are apparently healthy, shows considerable starch in all parts of the structure, even in the youngest growth. Crystals are somewhat abundant. In the older structure the starch shows a decided increase with the age of the tissues. During active growth the leaves contain a rather large amount of starch, chiefly in the palisade cells. Later in the season it becomes replaced by oily matter as the leaves ripen. Wood collected after the leaves have fallen, shows no appreciable difference from the conditions observed during the period of greatest activity. The difficulty of obtaining a specimen of pear wood which can be considered healthy, is very great and can only be appreciated by those who have made the effort. The foregoing diagnosis represents a healthy condition as perfectly as could be obtained from a native pear. A specimen was taken from a seedling Japanese pear in October, after the leaves were off the tree. The tree was in its fifth year of growth from seed brought directly from Japan and started at Amherst. The growth of the past season was exceedingly vigorous, and there was every external indication of health. An examination of the structure showed the pith, rays, and many of the wood cells to be densely filled with starch. In the liber only a few scattering grains occurred, while in the outer bark, each cell contained a little starch, the quantity increasing toward the periderm where the vitality is less. Crystals were somewhat abundant. Older growth showed an increase of starch in all the parts.

APPLE. *Pyrus malus*. L.

June. In the youngest growth, the sheath and rays are well filled with starch, as also most of the mesophlœum cells, while there is but little in the liber. Crystals are abundant. Occasional cells in the pith are well filled. As the growth becomes older the starch increases in all parts. The leaves show but little starch and considerable oily matter.* Crystals are numerous, and of two forms.

Early September. The season's growth shows half the pith, all the sheath, and many of the wood cells to be densely filled with starch. Crystals are abundant. Three-fourths of the outer bark cells are well filled with starch. These features do not change in the older growth. In the leaves, the starch is almost wholly replaced by oily matter, the few remaining grains being confined to the central cells. In November the conditions are essentially the same as observed in September.

March. In the growth of one year, the cells are well filled with starch in the pith. The sheath and rays are also well filled, but none of the wood cells. In the bark, about one-thirtieth of all the cells contain some grains of good size. Crystals are somewhat abundant in the liber. In the growth of two years and older, the starch increases in quantity, appearing in the wood cells, and more completely filling the rays, sheath, and bark. In the latter, about one-tenth of the cells, are fairly filled. Crystals remain abundant in the liber.

FLOWERING DOGWOOD. *Cornus florida*. L.

June. The earliest growth shows the pith to be devoid of starch, but that it contains many large crystals. The sheath and rays are empty, while in the bark only

*The appearance of oily matter in the leaves at this early period of growth, indicates a premature ripening which points to a diseased condition.

one or two rows of cells just outside the bast contain starch. Crystals are somewhat abundant as the growth becomes more matured during the first year, the starch becomes more abundant and appears a little in the pith, more so in the rays, wood cells, and bark. Growth of two years and more shows a marked increase of starch in the woody structure, but about the same in the other parts. The leaves do not show a great abundance of starch, which is confined to the upper palisade cells.

Early September. In growth of one season, most of the pith cells, all of the sheath, rays, and many of the wood cells are densely filled with starch. Crystals are abundant in the pith and bark. Some of the liber cells, and all of the mesophlœum cells are well filled. In growth of two years and older there is a general increase of starch, otherwise the characters are the same. The leaves show abundant crystals, a small quantity of starch, and an abundance of oily matter.

November. The distribution of starch in the various parts of the woody structure appears the same as in September, but nearly all the starch has disappeared from the bark.

March. In growth of one year, there is no starch in the bark, but crystals are abundant. All the rays, and many of the wood cells are fairly well filled with starch. No starch appears in the bark. In older growth, a few fine starch grains appear in the pith, while all the rays and many of the wood cells are well filled. In the bark, the starch is confined to the mesophlœum, where several scattering cells are well filled. Crystals are abundant.

SILKY CORNEL. *Cornus sericca.* L.

June. In young growth the pith is empty. The sheath, rays, and a few of the older wood cells are well filled, as is also the entire mesophlœum. There is occasional starch in the liber. Crystals are abundant in the entire bark in two forms. In growth of two years and upward, the characters do not change beyond a slight increase of starch in all the parts. In the leaves, all the cells are well filled with starch and crystals are abundant.

Early September. The pith contains no starch, but numerous crystals. The sheath, rays, and some wood cells are well filled with starch. Crystals in the bark are abundant. Many of the liber, and all of the mesophlœum cells, are from one-half to three-fourths full of starch. In the older growth, the distribution of starch and crystals remains the same with an increase in the quantity in all parts. In the leaves, the crystals are abundant, and most of the cells contain a large amount of starch, with some oily matter.

November. Wood collected after the fall of the leaves shows essentially the same quantity and distribution of starch in the various parts of the stem.

March. The large pith of the first year's growth is empty. The sheath is well filled, but the starch becomes scattering in the rays, and does not appear at all in the wood cells. In the bark, the starch occupies a small portion of about one-twentieth of all the cells. With the growth of two years, starch appears in many of the wood cells, and becomes more abundant in the sheath and rays, and somewhat greater in the bark. Crystals are abundant in the pith.

WHITE ASH. *Fraxinus Americana*. L.

June. The early growth shows an empty pith, but the sheath, rays, and many wood cells are well filled. There is also some starch in the liber, and in the mesophlœum, though in the latter it is chiefly confined to a few cells just external to the bast. Crystals are present in the liber, but are not very abundant. Growth of two and more years shows numerous crystals in the bark, with no starch in the pith, but an abundance in the rays, many of the wood cells, and in the whole bark—chiefly in the mesophlœum. In the leaves, all the cells are well filled, and the crystals appear to be few and small.

Early September. The growth of the first year shows a large and empty pith. The sheath, rays, and many of the wood cells are densely filled with starch. About half the liber cells and all the mesophlœum cells are densely filled. The starch is so abundant, that the crystals are obscured. There is no perceptible change of the characters in the older growth. The leaves show an abundance of starch in all the cells, with very little oily matter and few or no crystals.

November. Growth of one year shows an empty pith. The sheath, rays, and many of the wood cells are densely filled. In the bark, crystals are somewhat abundant, while three-fourths of the cells of the outer bark, and occasional cells in the liber are well filled. Growth of two years and older shows an increase of starch in all the parts.

March. Growth of one year shows an empty pith. Starch becomes abundant in the sheath, rays, and many of the wood cells. It also appears largely in the bark, chiefly in the mesophlœum. In older growth, the starch has the same general distribution, though it increases in quantity in the wood cells and bark.

ELM. *Ulmus Americana*. L.

June. The youngest growth shows the pith about half full of starch. The rays are well filled, even into the liber. In the mesophlœum, one-third of the cells are well filled. Crystals are fairly abundant. Older growth shows essentially the same features, with an increase of starch in the bark. The leaves are well filled with starch throughout.

Early September. The pith is empty, while the sheath, rays, and many of the wood cells are well filled. Crystals are rather abundant in the bark. Two-thirds of the liber, and from one-third to two-thirds of the mesophlœum cells are well filled with starch. Growth of two years and older shows the same features. In the leaves, most of the cells contain a small quantity of starch, while the oily matter is rather abundant. Crystals are somewhat abundant.

November. After one year of growth the pith is found to be empty, but the sheath, rays, and scattering wood cells are well filled. The terminal ray cells, as also many of the liber cells, are well filled. In the outer bark the crystals appear to be somewhat abundant, but the starch only fills about one-half of the cells and is chiefly found next the periderm. At the age of two years there appears a strong increase of starch in the wood cells, and a well defined, but less strongly marked, increase in the bark, chiefly in the liber, the starch-bearing cells becoming somewhat scattered. After two years there seems to be no material change.

March. The pith is empty, and comparatively little starch appears in the woody structure. In the bark, it is almost wanting. In the older growth there is only a slight increase of starch in the various tissues.

SLIPPERY ELM. *Ulmus fulva.* Michx.

Early September. In young growth the pith is empty. All the sheath, rays, and many of the wood cells are well filled with starch. All the cells of the bark are well filled. The crystals are large and abundant. In growth of two years and older, there is a general abundance of starch in all the tissues, but there is no perceptible increase over that in the growth of one year. The leaves contain a few crystals, no starch, but an abundance of oily matter.

BUTTONWOOD. *Platanus occidentalis.* L.

June. In early growth the pith is empty, while some of the rays, a portion of the sheath, and many of the liber cells are well filled. In the mesophlœum the starch is chiefly confined to one or two rows of cells bordering upon the bast bundles. Crystals are occasionally met with. As growth increases in age, and after the second year, some of the pith cells become full of starch. The latter also increases in the wood and bark, particularly in the mesophlœum. Crystals are rather more abundant. The leaves are all well filled with starch, which predominates in the palisade cells.

Early September. Growth of one season shows the pith and rays to be well filled with starch. Occasional starch is to be found in the liber, with the end of the rays well filled, while in the mesophlœum about one-half of the cells are well filled. Crystals are somewhat abundant. Growth of two years and older shows an increase of starch and crystals, chiefly in the bark. In the leaves one-half of the mesophyll cells, and all the palisade cells, are well filled.

November. The pith, rays, and scattering wood cells are densely filled with starch in growth of one year. The rays in the bark are also well filled, while only one-fourth of the mesophlœum cells contain starch. There are a few crystals. With the second year, the whole growth shows a strong increase of starch in the wood cells, and a slight increase in the bark, chiefly near the extremities of the rays.

March. Wood collected in the spring shows that the starch has decreased during the winter or early spring. While the pith remains well filled, there is much less in the wood and bark than was observed in the fall. The same relations of starch to age are, however, found to hold good.

HICKORY. *Carya alba.* Nutt.

June. In young growth the pith is empty, but there is a small amount of starch in the sheath. The rays are well filled, while but little starch appears in the bark except in the terminal ray cells. The crystals are large and abundant. With the second year the pith, sheath, and rays, as well as many of the wood cells, become filled with starch. There is also considerable starch in the terminal ray cells of the bark, but not elsewhere. The crystals are large and numerous. The starch is quite evenly distributed through all parts of the leaves, each cell being about half full.

Early September. In the growth of one season the entire pith, all the rays, and many of the wood cells are densely filled with starch. In the liber, the starch is chiefly confined to the terminal ray cells, while in the mesophlœum, four-fifths of the cells are well filled. Crystals are abundant. Older growth shows a general increase in the amount of starch in the various parts. In the leaves, the crystals are large and abundant, while there is little or no starch, except in the guard cells of the stomata.

November. From the youngest growth to that of two and three years, the distribution of starch shows no appreciable difference. The pith, rays, and many of the wood cells are densely filled. There is an abundance of crystals in the bark. The starch in the liber is chiefly confined to the rays, while in the mesophlœum almost all of the cells are well filled.

March. Growth of the first year is characterised by a pith densely filled with starch. The sheath contains little or none, but the rays and a few of the wood cells are well filled. In the bark, crystals are large and abundant, especially in the outer bark. In the liber, the starch seems confined to the terminal ray cells, while in the mesophlœum, one-third of the cells contain a fair quantity of starch, the grains filling about one-half of the cell cavity. Older growth shows a strong increase of starch in all the parts.

PIGNUT. *Carya porcina.* Nutt.

September. The pith is empty. The sheath, rays, and some of the wood cells are well filled with starch. In the liber the starch is confined to the terminal ray cells, while all the mesophlœum cells are about half full. Crystals are abundant. With the second year starch appears in some of the pith cells and increases in the bark. In the leaves starch is present in most of the palisade cells, while oily matter and crystals are somewhat abundant.

November. The youngest growth shows the pith and sheath cells, also all of the rays, and many of the wood cells densely filled with starch, while only one-half or two-thirds of the mesophlœum cells are well filled. Crystals appear abundantly in the bark. Growth of two years and older shows an increase of starch in all the parts.

March. The pith is full of starch. The sheath and rays, and occasional wood cells are well filled. There is no starch in the liber, but in the outer bark about one-twentieth of the cells are well filled. Crystals are abundant. Growth of two years shows a strong increase in the starch, particularly in the bark. The same increase is noted in growth of three years.

RED OAK. *Quercus rubra.* L.

June. In the youngest growth, all the pith cells appear devoid of starch, but they contain an abundance of crystals. All the sheath and ray cells are densely filled with starch, but there is none in the bark, except in a few cells just external to the bast. The crystals are large and abundant. In the second year and after, the pith is densely filled with starch, as also are the rays, sheath, and many of the wood cells. The starch is somewhat abundant in the liber and mesophlœum. The crystals are large and numerous. Starch is abundant in the leaves, especially in the palisade cells.

Early September. The young growth shows the pith and rays, as well as many of the wood cells, to be densely filled with starch. In the bark, nearly all the cells contain more or less. Crystals are very abundant. Older growth shows a general increase of starch in all the parts. In the leaves there is a large amount of oily matter, with comparatively little starch.

November. The condition of the wood at the close of the season shows that the pith, rays, and many of the wood cells are densely filled with starch, and that crystals are abundant in the bark. In the latter tissues, however, the starch is scattering and comparatively slight, but the quantity increases with age of the structure. In growth of two years and older, there is a corresponding increase of starch in all the parts with age.

March. In growth of one year, the pith is densely filled with starch. The sheath and ray cells are also well filled, but no starch appears in the wood cells or bark. Crystals are very abundant in the bark. In growth of the second and third year, the starch continues to fill the pith and rays, and appears in many of the wood cells, those bearing starch being curiously disposed in circles concentric with the pith. In the liber, some of the ray cells contain starch, as also occasional cells of the mesophloem. Crystals are abundant.

CHESTNUT. *Castanea vesca.* Gaertn.

June. During the earliest growth the pith is empty, and only a little starch appears in the sheath and rays, with scattering and well filled cells in the bark—chiefly in the liber. Crystals are rather abundant. With the second year, starch appears in a number of the pith cells and shows a slight increase in the other parts. In the leaves the cells are well filled with starch, and crystals are abundant.

Early September. Growth of the season shows the pith and rays, as well as many of the wood cells, well filled with starch. Crystals are abundant in the bark, where one-third of all the cells are densely filled with starch. With growth of two years and older, the increase of starch occurs chiefly in the wood and pith, where the starch-bearing cells become densely filled. There is very little increase of starch in the bark. The leaves show only a few scattering grains of starch, the majority having been replaced by oily matter.

November. The growth of one year shows that the pith, rays, and many of the wood cells are well filled, as also the terminal cells of the rays and scattering liber cells. There is almost no starch in the mesophloem, though crystals are somewhat abundant and small. Increasing age shows a corresponding increase in the amount of stored starch in both the wood and bark cells.

March. In the youngest growth the pith cells are densely filled. The sheath and rays are also well filled, but the bark contains no starch. Crystals are somewhat abundant in the bark. Occasional wood cells are well filled. In the growth of two years and older, there is an increase of starch in all the tissues, but it does not become very abundant in the bark.

BEECH. *Fagus ferruginea.* Ait.

Early September. The pith and some of the wood cells are densely filled in growth of one season. In the liber there is little starch, but from one-half to two-

thirds of the outer bark cells are well filled. In growth of two years and older, the starch shows a strong increase in all the parts. In the leaves, there is an abundance of oily matter, but the starch is limited and confined to a few of the central cells.

November. There is a decided increase of starch throughout the woody structure, but there is little starch in the bark, though crystals are abundant. Growth of two and more years shows a corresponding increase in the amount of starch.

March. In growth of one year the pith is well filled with starch. The rays and some wood cells are also well filled, but there is very little starch in the bark. Crystals are somewhat abundant. In older growth, the amount of starch in the various parts is very much increased.

PURPLE BEECH. *Fagus sylvatica*. L. Var. *purpurea*.

Early September. The pith and ray cells, as also many of the wood cells, are densely filled with starch. In the liber there is very little, but in the outer bark it becomes somewhat abundant, filling one-half to two-thirds of the cells. Crystals are abundant. At two years and older, there is a general increase in the quantity of starch. The leaves contain very little starch, but an abundance of oily matter.

November. The distribution of starch in the woody structure seems to remain the same after the leaves fall, but there is a conspicuous increase of starch in the bark. Age shows the same increase of starch in the tissues as was noticed in previous cases.

March. Growth of one year shows that the pith is full of starch. All the rays, and many of the wood cells are fairly well filled. About one-fourth of the bark cells are fairly filled. In growth of two or more years, there is no marked increase of starch.

BLACK BIRCH. *Betula nigra*. L.

Early September. The pith, rays, and many of the wood cells, as well as many of the bark cells, are densely filled with starch. Crystals of calcium oxalate are also abundant in the bark. There is no perceptible variation in the quantity of starch in the older structure up to a growth of four years. In the leaves, the cells are fairly well filled with starch, and there is an abundance of oily matter.

November. The growth of the first season shows that the pith, rays, and many of the wood cells are densely filled with starch. There is also an abundance of crystals in the mesophlœum, where nearly all the cells are full of starch. There is little or no difference to be observed in the quantity of starch in the older growth.

March. In the first year's growth the pith cells contain little or no starch, but in the second year and after, the cells are more or less densely filled. In the medullary sheath and rays, the starch is abundant, increasing in quantity after the first year of growth. The starch in the cortical region is small, but it increases somewhat after the first year. In the liber it is almost exclusively confined to the terminal ray cells, while in the outer bark it is found in scattering cells as groups of small grains, which rarely more than half fill the cavity.

GOLDEN WILLOW. *Salix alba*. L. Var. *vitellina*.

June. The youngest growth shows no starch in the pith and wood cells, a small quantity in the rays and mesophlœum, in the latter being confined to a few cells just external to the bast bundles. Crystals are somewhat abundant. As the growth

becomes older, the starch shows no special increase in the wood, but increases somewhat strongly in the bark, where half of the cells are well filled. Starch is uniformly distributed through the tissues of the leaves, though each cell contains but little.

Early September. Growth of one season has few pith cells, all the sheath, ray, and many of the wood cells densely filled. The liber is half filled, while all the cells of the outer bark are completely filled. Crystals are small but abundant. With two and three years, no change in the quantity of starch can be detected. The leaves contain an abundance of crystals and oily matter, but no starch appears except in the guard cells of the stomata.

November. Wood collected after the fall of the leaves, shows essentially the same distribution and quantity of starch in the various tissues as noted in September.

March. In growth of the first year the pith is devoid of starch. In the sheath and rays it is found sparingly, but more largely in the wood cells. In the liber it is found only in small quantity, while in the mesophlœum quite a number of cells contain some grains. In growth of two years and older, there is a slight increase in the quantity of starch in the various tissues.

From the foregoing facts, it appears that the leaves of trees contain an abundance of starch during the period of the plants' greatest activity; but that, as the time of ripening approaches, the amylaceous material previously formed by the assimilative process, undergoes certain modifications, becomes transformed into oily matter or a soluble form of starch for transfer to the more permanent structure of the plant, where it becomes stored for use in future growth before the earliest vital activity of spring is capable of bringing the assimilative power again into operation. This, so far as our facts will enable us to judge, is a general law which finds exception only in a diseased condition, when the chlorophyl is imperfectly formed, and is therefore incapable of developing the products in assimilation in a normal manner. Examples of this are conspicuous in the discolored leaf of the peach yellows, and in the abnormal leaf of the peach and apple curl.

Plants which form a large amount of permanent structure as an essential part of their frame work, seem to contain reserve material in the form of starch at all seasons of the year. This may be present as a residue from that stored the previous year in excess of the requirements of the plant, or it may be present as the immediate product of the assimilative processes then in operation—one or both combined. We will thus find more or less starch in the various tissues, even during the time of greatest activity, when all such material is supposed to contribute in the greatest degree to the formation of new cellular structures, but in the healthy tissues the quantity is much less at this time than at any other period of the year, possibly, with the exception of that period immediately preceding the bursting of the buds in the spring, when most of the reserve food has been brought into a readily available form for the growth of the young tissues, and so is not to be recognized in a granular form. An important exception to this is to be found in certain diseased structures.* Comparing the wood of various ages during this time, it will be seen that the newly formed wood and bark contain much less starch than will be found in the same parts of older growth. As the season progresses, and

*Diseases of Plants. H. F. Series III; No. 2.

the tissues become more mature, there is a gradual accumulation of starch in all of the structure, and this seems to continue until about the middle of September, when, with the final ripening of the leaves and cessation of growth for the season, the culminating point seems to be reached. After the leaves have fallen and the trees have fully entered their winter condition of rest, there seems to be no change beyond that noticed to have occurred by the middle of September, except in the *Cupulifera*, where we find a decrease of starch in the cortical region between the middle of September and the last of November in *Quercus rubra*, *Castanea vesca*, and *Fagus ferruginea*.

The storage of a given quantity of starch in the autumn, does not signify that the plant is capable of preserving it intact until the approach of active growth in the spring. On the other hand, it seems to be a general law to which no well defined exception has appeared in the course of our present work, that there is a gradual solution of the reserve material, either during the winter or in very early spring when the first movement of the sap occurs, and before there is any formation of new structure.

The first accumulation of starch is to be found in the pith, or its immediate vicinity, next in the woody structure, and last of all in the bark. As the wood becomes older, year by year, there is a corresponding increase in the amount of stored starch in the various tissues, though this seems to find a limit somewhere about the third or fourth year, but the relation holds good, even for growth of the same season, since the young growing tips of branches always contain less starch than the tissues formed earlier in the season.

The bark stores less starch than the woody structure, receives its accumulations somewhat later, and parts with it earlier in the season. Yet another distinction is to be observed in the fact that while the outer bark may be filled with starch, the liber is generally empty, whatever starch it may contain appearing first in the rays. The deposit of starch in this tissue is, therefore, always last, and its solution first. The wood is the most permanent structure of the entire plant, while the bark is the general center and the liber the special center of vital activity. There is thus a direct correlation of age and vitality to the storage of reserve material; or, to state it in a different form, those tissues, other things equal, which possess the least vital energy, show the greatest capacity for the storage of starch, and the least power to convert it into plant structure. This expression also seems to receive confirmation in the case of plants of more succulent growth.*

Special physiological peculiarities—and it will be interesting to observe how far they are to be considered family characteristics—are more or less intimately connected with exceptions to the general law of distribution, for while 52.4 per cent. of all the specimens examined show that the young bark stores a comparatively large amount of starch during the growing season, 47.6 per cent. show the quantity of starch to be limited or altogether wanting. In the former class we have the plum, red cherry, black cherry, pear, apple, silky cornel, elm, pignut, beech, purple beech, and black birch; while in the latter are included the peach, grape, maple, flowering dogwood, ash, buttonwood, hickory, red-oak, chestnut, and golden willow, all of these latter storing little or no starch during the first year's growth until late in the season. These facts show rather conclusively that a diagnosis of disease based upon

* Leydhecker. Versuchs-stat., VIII.

the amount of stored starch present in the tissues, will be most accurate when the cortical structure of the first year's growth is made one of the prime considerations.

81.8 per cent. of all the examinations made, show a direct relation between the stored starch in the cortical structure, and the quantity of calcium oxalate present in the form of crystals. So generally is this true, that it was found possible to determine, with approximate accuracy, whether or not the older tissues would contain much starch, from the quantity of crystals observed in the young structure. Exceptions to this are not wanting, however, for in the hickory, pignut, chestnut and red oak, there is generally a great abundance of crystals, but the starch is not deposited in proportionately large quantity. Nor even where this relation is best exhibited, do we find a uniformity of proportion at all seasons. During the time of active growth, there frequently will be found numerous crystals and but little starch, but this latter usually increases in a corresponding degree, either in the older structure or in the young growth later in the season. This relation is quite in accord with the known formation of oxalic acid, through the slow oxydation of the carbohydrate compounds. Direct experimentation seems to further indicate that there is an appearance of calcium oxalate in the tissues simultaneously with the rapid absorption of lime by the plant, and Kellerman has been led to the conclusion that the function of the lime is closely connected with the consumption of the carbohydrate.*

Analysis of the diseased peach shows that there is a greater amount of both starch and lime than in the healthy structure. The generally depauperate structure of the diseased peach wood, however, would seem to offer a contradiction of Kellerman's views that the solution of starch, through action of the lime, is for the promotion of cellular formation. If we are to believe that the lime exerts a solvent action on the carbohydrates, then we have, in the excessive accumulation of starch in the diseased peach, a strong argument in favor of the assumption that the retarded physiological activity is to be found in an abnormal osmotic action, by which the elaborated material is prevented from distribution to the various parts where it is demanded by growth.

Whatever the specific functions of the lime in the plant may be, it seems, in certain cases at least, to bear a more or less direct relation to an abnormal condition, and the excessive storage of starch by the diseased tissues,† a relation which does not conflict with the generally accepted view that calcium oxalate is a waste product of the plant, that being the form in which the two components are brought into a harmless form while yet in the living tissues.

Fungi appear to be parasitic upon living organisms independently of conditions of health or disease. Fungus forms have frequently been observed on the dead tissues of the outer bark, even under conditions where disease was known to be absent.‡ No instance has yet come under my observation where fungus growth penetrated the healthy structure. Under certain abnormal conditions, which may be either general§ or specially localized,|| the fungus may penetrate the interior structure, which then rapidly becomes involved in the process of decay.

* Landw. Versuchs-stat, 1880, XXV, pp. 25-38.

† Trans. Mass. Hort. Soc., Part I, 1882, pp. 122 & 127.

‡ Ibid., p. 128.

§ Ibid., p. 129.

Monatschr. Deut. cher Gartn. 1880, p. 70, and Unters. fürstbot. Inst., München. I, 1880, pp. 145-159.

The conclusions to which these facts point may be summarised as follows:

1.—While, in general, plants store reserve material at the close of the growing season, this law cannot find specific application in all cases and for all tissues.

2.—Woody plants generally contain reserve material in their permanent structure during the period of active growth, but the presence of starch in the cortical tissues during this time is variable in different species, and depends upon the special physiological functions of the subject.

3.—The reserve starch is least during active growth and greatest just after the fall of the leaves. [Note exceptions.]

4.—The amount of stored material is most variable in the bark, and least variable in the wood and pith.

5.—Reserve material appears most abundantly in the oldest tissues and those which are most strongly lignified; least abundantly in the tissues where the vitality is greatest.

6.—The storage of the carbohydrate is first in the old and lignified cells, and last in the most active structure.

7.—The solution of the stored starch is first in the active parenchyma cells, and last in the permanent tissues.

8.—There is a gradual solution of the stored starch during the period of rest.

9.—Leaves normally contain an abundance of starch during the period of their greatest activity, but as they ripen the starch is replaced by oil.

10.—There is in general a well defined relation between the reserve carbohydrates of the plant and the calcium oxalate. An increase of the latter being correlated to an increase of the former.

11.—Fungi do not penetrate normal cellular structure, but remain confined to the dead tissues of those of low vitality.

HOUGHTON FARM.

EXPERIMENT DEPARTMENT.

SERIES III.—No. 2.

PEACH YELLOWS,

BY

D. P. PENHALLOW, B. S.

1882.

PEACH YELLOWS.

The facts embodied in the following paper have been brought together after two years of constant labor in examining the various questions considered. The subject was first undertaken at the request of Dr. Goessmann, of Amherst, who had already entered upon an investigation of the disease from a strictly chemical standpoint, and to whom is to be credited the chemical treatment of the subject; such of the facts obtained by him being embodied in the present paper as are essential to its complete presentation. A thoroughly systematic course of inquiry which should embrace field experiments and observations upon an extended scale, were undertaken with the opening of the last spring. The plan involved a thorough inspection of orchards; an intimate acquaintance with the ideas entertained by practical peach growers; extended field experiments to determine the value of special fertilization in arresting disease, and an exhaustive examination of healthy and diseased structures under the microscope. The results are given in the following text.

One of the earliest obstacles to the successful prosecution of our work was found in the absolute indifference to the subject manifested by the great majority of peach growers. Many showed no interest at all. Others suspected us of being agents for the sale of fertilizers, while many were so firmly grounded in the belief that the ways of their fathers could not be improved upon, and that no prevention could possibly be applied, that we could only leave them to their own convictions. In a few cases, however, it was refreshing to find men who had an intelligent appreciation of the question at issue. In order to obtain some facts which were only to be gathered from experience in cultivation, and avoid as far as possible the assertion that such questions are usually examined by men of no practical experience, an effort was made to give practical fruit growers an opportunity to present their views. Circular blanks of the following form were distributed to 150 prominent peach growers in New Jersey, Massachusetts and New York.

PEACH YELLOWS.

Please observe carefully, fill in your answers concisely, and return as soon as the fruit ripens.

Make careful distinction between Blight and Yellows.

- 1.—At what time of year does the disease first appear?
- 2.—Does the disease first appear before or after the tree has come into bearing, or is that a matter of indifference?
- 3.—Which is the more liable to attack, seedlings or grafted trees? Is there any difference?
- 4.—What is the first indication of disease in an apparently healthy tree?
- 5.—Where does it first appear?
- 6.—Is the disease localized, *i. e.*, confined to particular parts of the tree, or is the whole tree gradually involved?
- 7.—When a tree is attacked, how long before it dies?
- 8.—Is there any difference in the health of trees on account of location, as between high land and low, or on account of different exposure?
- 9.—How old are your trees?
- 10.—How long has the disease run?

- 11.—What manures have been applied?
- 12.—Has there been any apparent effect?
- 13.—What has been your method of treating diseased trees?
- 14.—What has been the result?
- 15.—How is the fruit affected when it forms before disease is evident?
- 16.—How is the fruit affected when it forms on the diseased tree?
- 17.—How long has the disease been known in your locality?
- 18.—What has been the effect upon the annual yield of fruit?
- 19.—How long have you cultivated the peach?
- 20.—Has the disease increased or decreased during that time?
- 21.—How many diseased trees have you?
- 22.—How many healthy trees have you?
- 23.—What is the yield in bushels (for this year) of the healthy trees.

They were requested to fill out and return at the end of the season after the fruit was all gathered. At the same time directions for the treatment of trees, according to the best methods at present known, were distributed. Of the whole number of persons to whom circulars were sent, only four responded with answers to the questions.* They were Samuel Hartwell, of Lincoln, Mass.; S. C. Damon, of Lancaster, Mass.; E. P. Tomlinson, of Stockton, New Jersey, and David Sands, of Marlboro, New York. Personal observation, however, has enabled us to supply much that the circulars were intended to accomplish. One important list of data still remains wanting. It is of great importance in the industrial aspects of a question, like this, to fully bring out the commercial value and the necessity of preserving an industry without deterioration. To do this, statistics are absolutely essential, but there is not a State, or National Board, or Department of Agriculture from which such statistics can be obtained; much less can they be obtained from the fruit growers themselves. It certainly seems as if an important work would be accomplished by the Department of Agriculture, at Washington, if a portion of their funds were expended in the collection of important statistics of this kind.

The present discussion of this question has not been undertaken because the disease is a new one, nor because the subject has lacked previous discussion and examination. As a matter of fact, the difficulty is one of such long standing, that it becomes a matter of some surprise that it has not received careful consideration from a scientific standpoint long since. It has certainly been well known since 1800. Where it was first recognized is a matter of considerable doubt, though the best sources of information seem to point to Pennsylvania as the birthplace of the trouble.† The earliest public recognition and record of the disease, appears to have been made in 1806. Since then, articles upon the subject, and complaints of the ravages of the disease, have multiplied yearly, until, latterly, the subject has assumed such

* The result of our efforts in this direction show that there is something wrong. When fruit growers cannot afford the time required to fill out so simple a matter as a short circular, and return it at no expense to themselves, it argues very strongly against them. Scientific men ask these things of the practical fruit grower, that they may directly benefit him, yet he not only refuses the information, but turns with the accusation that these questions are treated of by men of no practical experience. It is generally supposed that a man whose pecuniary interests are concerned is the first to recognize a proffered benefit. The utter indifference of fruit growers to the calls upon them for information, permits us to believe, either that they do not care, or that they do not make those careful and close observations upon the condition of their orchards which a successful business demands.

† Rutter on the peach.

importance, as to demand large attention from our horticultural societies, and make it imperative that some steps should be taken, looking to the discovery of the true nature of the disease, and the proper applications for its arrest and cure. From its appearance in a few localities early in the present century, the disease has spread, and its effects have been multiplied, until now it is dreaded by every fruit grower, and looked upon by them as something that cannot be avoided. The question has not lacked discussion by practical horticulturists, and many theories as to its nature have been set forth, and multitudes of so-called remedies tried with varying effect. Only in a few instances has the subject been regarded by men of scientific qualifications, and then it received but partial examination. The question has been taken up, therefore, because of the great interests involved, and the necessity of a thorough scientific examination of the entire subject. It will be well to present the views generally entertained by fruit growers before we proceed to a further examination.

But one opinion can be and is entertained with regard to the general symptoms of the disease, so far as they appear externally, and many of the best fruit growers are careful to make a critical distinction between the yellows and other troubles which may be mistaken for or confounded with it. One of the most recent scientific papers on the subject, lays particular stress upon the identity of blight in the pear and the peach yellows,* but, as pointed out by me in a recent paper,† there is a clear distinction between blight in the peach and pear, and the disease known as peach yellows; and in a recent communication from Prof. Burrill, he accepts my "idea of the two diseases, though I have no further proof."

Mr. Hartwell, of Lincoln, Mass., reports that "thirty to forty years ago, peaches were grown in great abundance and perfection in this vicinity, but for the last twenty years have been almost abandoned." In New Jersey, where the ravages of the disease have been more seriously felt than elsewhere, the southern counties were formerly the center of the peach industry for the entire state, but owing to the prevalence of the yellows, the peach orchards have been gradually moving northward until at the present time, the counties of Morris and Hunterdon have the largest interests involved, and the prospect is that a few more years will see even these localities deprived of the industry. Fruit growers generally represent that where land has once produced a diseased orchard, it will be impossible to again raise peaches successfully, but several well-authenticated instances have been brought to my notice, where trees have again been planted and done well for a certain time, after the land has been allowed a period of rest. This belief is common with that, that the soil itself contains the germs of the disease; hence the tree planted where a diseased tree formerly stood, will in turn become unhealthy. This view receives additional weight from the asserted fact (?) that disease travels down hill with the wash of the slope. There is great unanimity in the belief that the disease is contagious; that it is propagated not only by proximity of the subjects, but that it may be spread by contact of the trees, by interlacing of branches, and by the pruning knife.

One great source of the disease is claimed to be in the nursery stock usually sold to orchardists, and this complaint seems to be reasonable, since if trees are raised from seed produced by a diseased tree, the offspring must inherit the qualities of the parent. It is generally recognized that the young growth is first involved

* Burrill. *Am. Nat.* July, 1881.

† *Trans. Mass. Hort. Soc.*, Part I, 1882.

in disease, and that the older growth is gradually involved, the roots being diseased from the first. While the disease may, and often does, appear in the seedlings, it is most common for it to appear after the tree has fruited, and its course is run and the tree killed in from two to three years. The cause is believed in most cases to be a fungus growth on the roots, though a writer some twelve years ago, expressed his belief that the disease had its origin in bad cultivation, or rather in long cultivation on the same soil. He further remarks that, at an early day in this country, the yellows were unknown; and in newly cultivated districts and fresh soil, it is never seen except when introduced by diseased trees.* So great has been the destruction among peach orchards, that even so long ago as 1863, the belief that the peach is short-lived, and after a few crops begins to fail†, commenced to gain currency, and has steadily increased since then. So true is this, that to-day, the peach-growers of New Jersey consider an orchard worth nothing after the age of nine years. At that time they root out all the trees as they would so many corn stumps, and use the land for general crops, planting a young orchard of seedling each year to make good the loss. Occasionally, however, we find testimony to the long life of the tree, even at the present time. Speaking of its cultivation in the south, one writer affirms that the peach is long-lived, healthy and vigorous throughout Florida, and is not subject to injuries from the peach-borer or the diseases which so universally afflict the fruit in the northern States.‡

All the remedies that have been tried, have been based on the fungoid origin of the disease, with few exceptions. Efforts have been made to destroy the fungus without restoring the normal vitality of the plant. To this end, washes, sulphur compounds, caustics and similar things have been tried with poor success. In some cases, wood ashes have been applied with certain good results, but in general, the necessity of giving the plant a proper amount of good, nourishing food has been entirely overlooked or ignored. One of the most rational views in the matter that has come to my notice, was expressed so long ago as 1865, when it was recommended that "after the first crop the trees should receive one hundred bushels of wood ashes, or three hundred pounds of Peruvian guano, or four hundred pounds of some standard super-phosphate to the acre. This will restore the trees, and prepare them for the next year's crop."§ How far these various views are justifiable in the light of scientific research, will appear from the discussion of the various points as they appear. It is manifest, however, that at least some of these notions have been borrowed from certain works on the peach, and are not the direct result of observation and experience on the part of the fruit grower.

CHEMICAL EXAMINATION.

The necessity of supplying plants with a proper amount of food, if we would have them make a healthy growth, and perform their numerous and varied functions without deterioration, is well recognized by all scientists of the present day, and has been steadily gaining in recognition since the time when Liebig first announced the principles of fertilization in 1840. The precise relation which the mineral constituents of the soil bear to the organic products of the plant, has by no means been

* Rept. Dept. of Agriculture, 1870, p. 520.

† Ibid., 1863, p. 352.

‡ Ibid., 1867, p. 146.

§ Rept. Dept. of Agriculture, 1865, p. 191.

fully determined; and though much has been done in this direction by various investigators, much yet remains to be accomplished. It is evident, however, that if we are to gain a clear insight into the laws of health and disease in plants, we must go back to the laws governing nutrition, and apply in a general sense, the same principles that are found to operate in the animal system. With a clear knowledge of the chemical constitution of the various parts of the vegetable economy, and a critical comparison of this composition in health and disease, we may then proceed intelligently to trace the specific relations of an abnormal structure and conditions to peculiarities of environment. It thus appears that a chemical inquiry is at the basis of an intelligent examination of the questions involved. It was shown some years since that, when plants are deprived of certain elements of food, the growth becomes abnormal, and certain peculiarities of cellular structure and contents appear as the result of this disturbance in the normal functions of the plant.* The facts developed in these experiments find a very close parallel in the later experiments of Dr. Goessmann, concerning the conditions incident to a diseased state in some of our fruits.† His analyses of peach wood and fruit, in conditions of health and disease, are as follows:—

FRUIT OF CRAWFORD'S EARLY.		HEALTHY.	DISEASED.
Ferric oxide, Fe_2O_3		0.58	0.46
Calcium oxide, Ca O		2.64	4.68
Magnesium oxide, Mg O		6.29	5.49
Phosphoric acid, P_2O_5		16.02	18.07
Potassium oxide, K_2O		74.46	71.30
		100.00	100.00
BRANCHES OF CRAWFORD'S EARLY.		RESTORED.	
Ferric oxide		0.52	1.45
Calcium oxide		54.52	64.23
Magnesium oxide		7.58	10.28
Phosphoric acid		11.37	8.37
Potassium oxide		26.01	15.67
		100.00	100.00

It should be remarked here, that the tree marked restored, was one which had been brought into a thoroughly healthy condition from a badly diseased state. These analyses show but little variation in the magnesium oxide, somewhat more in the phosphoric acid and ferric oxide, and a most striking relation between the calcium and potassium oxides. In fact, this relation is reciprocal and shows that while the former increases in the diseased structure, and decreases in the healthy, the latter increases in the healthy and decreases in the diseased. So far as the lime is concerned, its relation to a diseased condition, as shown here, is curiously parallel with its presence in the form of oxalate in the bark of many trees, and the relations which it bears to the storage of starch.‡ A very important influence is to be attributed to the action of chlorine. While potash appears to influence the formation of starch, chlorine seems to be essential for its normal distribution to various parts of the

* Nobbe, Schroeder & Erdmann, Chemnitz, 1871. Leydhecker. Versuchs-stat. VIII, 177.

† Trans. Mass. Hort. Soc., Part I, 1882.

‡ H. F., Series 111, No. 1.

plant where it is demanded by the requirements of growth. This is the conclusion to be derived from experiments both past and present, for it is found that in certain cases at least, the sulphate of potash is not efficacious, and the restoration of the diseased structure to a normal condition is only brought about by the chloride.

In 1878, Dr. Goessmann undertook an experimental demonstration of the questions involved by treating diseased trees with a phosphatic fertilizer in connection with muriate of potash. The trees so treated were restored to a condition of health, and up to the present year, when no fruit was produced on account of the buds being winter-killed, the trees have produced fruit which have brought the best market prices. It was from such a tree that the wood for the analysis given was selected. These feeding experiments have been extended by me during the past year, nearly one hundred trees being selected for that purpose. Sufficient time has not elapsed to enable us to judge of the effects of the treatment, but some of the trees seem to give indications that a good effect has been produced. A determination of this kind can not be completed in one season. The first year serves to remove a large body of the diseased structure and introduce the elements of health into the general system, and not until the second year can we reasonably expect to witness the actual development of healthy structure upon the basis so provided.

MICROSCOPICAL EXAMINATION.

The methods employed in the microscopical examination were identical with those employed in the determination of the normal conditions of cellular structure.* The examinations of wood and bark have embraced specimens collected at various seasons of the year, in natural conditions of health and disease, and the diseased structure after being restored to health. The facts gathered have been obtained from constant work of the last two years, and are of such number and character as to justify us in the belief that a reasonably correct insight into the true pathological conditions has been obtained. The results of our work of the first year are embraced in a paper read before the Massachusetts Horticultural Society in March last,† and the following results of the past year's work offer a striking confirmation of the statements and conclusions therein contained.

WOOD FROM DISEASED TREES AFTER BEING RESTORED, COLLECTED IN WINTER.

Growth of one year:—Pith empty. Rays and sheath well filled with starch. No starch in the bark, but crystals somewhat abundant. Structure of the bark normal. Growth of two years shows practically no change from the preceding.

WOOD FROM A HEALTHY TREE NEVER DISEASED, COLLECTED IN WINTER.

Growth of one year:—Pith cells all empty. Sheath, rays, and some of the wood cells densely filled with starch. Most of the rays in the bark well filled. No starch present in the outer bark cells, but crystals somewhat abundant and very large. Figs. 1 and 2, Plate I. were taken from this specimen. Older growth shows that there is but little change in the distribution of starch beyond a slight increase in the wood.

WOOD FROM A NATURALLY HEALTHY TREE, MARCH, 1882.

Growth of one year:—Pith entirely devoid of starch. Sheath as well as the medullary rays well filled. All the bark cells are almost devoid of starch, only scat-

*H. F., Series 111, No. 1.

†Trans. Mass. Hort. Soc. Part 1, 1882.

tering grains being found here and there. Crystals of calcium oxalate are quite abundant, particularly in the liber. Fungus growth abundant on the outer bark. Growth of two years shows an increase of starch in all the parts except the outer bark, a slight increase being observed in the liber. Growth of five years shows nothing different from this.

Wood collected in June shows an empty pith, sheath and rays containing some starch, and the bark cells devoid of reserve material in growth of one year. The older growth shows an increase of carbo-hydrate in all the woody structure, and a slight increase in the cortical region, but this does not extend beyond a few scattering grains.

WOOD COLLECTED IN SEPTEMBER, 1881-82.

Growth of one year.—Starch is present in occasional pith cells. All of the sheath and rays full. Crystals rather abundant in the bark. Starch wanting in the cortical region, or present only in the form of a few scattering grains. Growth of two years shows only a slight increase of starch in all the permanent structure, and only a slight increase in the bark.

These facts show, therefore, that the normal condition of the healthy peach wood is represented by the storage of reserve material in the woody and medullary systems, but its almost complete exclusion from the cortical region; that the effect of seasons upon the carbohydrates in the plant is the same as already determined;* that age operates to increase the starch in the various parts of the structure, and that calcium oxalate is somewhat abundant, confirming the conclusions already presented on previous occasions.† Other important features of the normal condition are to be found in the characters of the cells themselves, with regard to their form, size, and disposition. There is practically no difference to be detected in these respects, or in those previously cited, between the naturally healthy structure and that which has been restored from a state of disease, a fact of the utmost significance in demonstrating the value of the special treatment recommended. The normal bark shows that the cells are of irregular form, of very variable size, and irregularly disposed with intercellular spaces here and there (Plate 1. Figs. 2 and 4). The wood shows a fairly open structure, ducts being distributed throughout the entire growth of each year. The wood cells generally average 835 to the centimetre in radial direction, and exhibit the appearance represented in Plate 1, Fig. 5.

DISEASED WOOD. WINTER COLLECTION.

Growth of one year :—Crystals in the bark abundant. Structure of the cells abnormal. Many of the liber cells, particularly those of the rays, densely filled with starch. Most of the mesophlœum cells densely filled. Pith cells empty. Starch present in all the sheath cells, and in most of the rays and some of the wood cells. Crystals abundant in the bark. Older growth of the same year shows the bark densely filled with starch in all the parts, and a general increase in the other structure. In growth of two years, no change can be noted, owing to the great abundance of starch in the growth of the first year.

* H. F. Series 111 No. 1.

† Trans. Mass. Hort. Soc., Part I, 1882.

WOOD OF TREE AFFECTED WITH CURL. 1882.

Growth of one year :—Structure of the bark abnormal. The tissue shows many large intercellular spaces and loosely arranged cells. Bark developed in radial protuberances which give a more or less angular form to the stem, while the whole internal structure is quite abnormal. Crystals of calcium oxalate are very abundant, particularly in the liber. Starch present in the liber cells, especially in the terminal ray cells, and it also densely fills a row of cells just outside the bast. As the growth becomes older, the starch increases in all parts, and densely fills the greater part of the mesophlœum. Structure of the leaf abnormal. Tissue thick and pulpy. Intercellular spaces abnormal and the palisade cells greatly modified, their main axis being generally parallel with the blade of the leaf. Starch grains present chiefly in the cells of the upper surface, scattering in other cells. *Exoascus* and other fungi abundant. (Plate 2, fig. 4).

DISEASED WOOD. SEPTEMBER 1, 1882.

Growth of one year :—All the sheath and ray cells well filled with starch. The mesophlœum is fairly normal in structure. Crystals large and abundant. All the cells, liber as well, contain from 1-3 to 2-3 their capacity of starch. Most of the pith cells empty.

Growth of two years :—Pith cells empty. All the sheath and rays well filled with starch. Structure of the bark somewhat abnormal. Starch much more abundant than in the young growth.

DISEASED WOOD, SEPTEMBER 12, 1882.

Growth of one year :—Sheath, rays, and some of the wood cells densely filled with starch. Crystals in the bark abundant. About half the liber, and all the mesophlœum cells full of starch. Crystals in the pith abundant. Older wood of the same year's growth shows an increase in the starch in all the parts. These features are the same in the growth of two years.

DISEASED WOOD, SEPTEMBER 12, 1882.

Growth of one year :—Pith empty. Sheath, rays, and a few wood cells, as well as half the liber and all the outer bark cells densely filled with starch. Structure of the bark abnormal, and crystals abundant. In growth of two years the structure shows an increase of starch in all the parts, particularly in the bark.

DISEASED WOOD, NOVEMBER, 1882.

Growth of one year :—Pith empty. Sheath, rays and all the cells of the outer bark densely filled with starch. Structure of the bark abnormal. Crystals somewhat abundant. Growth of two and three years shows an increase of starch in the various parts so far as it is possible to detect it.

These represent the collective facts of numerous examinations. From them it is seen that the entire structure of the diseased wood and bark presents peculiarities in striking contrast with the same tissues in the healthy growth.

The bark cells are of an oblong shape, present considerable regularity of form and but little variation in size, and are almost invariably disposed in rows running parallel with the periderm, the major axis of the cell tending in the same direction. The intercellular spaces are frequent and large (Plate 2, figs. 1 and 2). The wood

presents remarkable density of structure and diminution in the size of the cells (Plate 2, figs. 1 and 3). The latter average 1075 to the centimetre in radial direction. A comparison of Plates 1 and 2 will show conclusively that these features are typical of the diseased state and are of the utmost importance in a correct diagnosis. In this case it appears, therefore, that while the deposition of reserve material follows the same laws with reference to age and season as found to operate in the healthy structure, yet those laws are largely controlled and modified by the conditions under which disease of the structure is promoted.

It will occur to many that the facts just set forth could hardly be obtained without prejudice in favor of preconceived notions as to what might constitute healthy and diseased conditions. One answer to all such surmises will be sufficient. The difficulty of forming unbiased opinions in cases of this kind was fully recognized in the beginning. To avoid the possibility of anything of the kind, all the specimens for examination were placed in numbered bottles, the numbers referring to a description in a special note book. The examinations were conducted, and the various specimens designated by means of the numbers alone, and not until after a given specimen was finished did I allow myself to consult the notes. In this way judgment was based solely upon the character of the structure as it appeared.

EXTERNAL CHARACTERISTICS.

Among the external features which characterize the yellows, we must take into consideration the formation of the fruit, the formation of the wood, the color of the bark, and the size and color of the foliage.

It is regarded by fruit growers generally that the earliest symptoms of the disease are to be detected in the fruit. The production of this being the grand effort in the life of the plant to which all other things are subordinated, we might reasonably expect, from theoretical considerations alone, that whatever disturbs the normal functions of the plant will manifest itself most readily in those parts destined for the perpetuation of the species. But this seems to have actual foundation in observed facts, for I find that trees frequently display abnormal fruit when the leaves and general formation of the wood indicate nothing of a special disorder. The fruit ripens prematurely, often shrivels on the stem, has an unnatural color, becomes abnormally velvety, develops an unnatural, insipid flavor, and the immature fruit of one season persists through the winter and late into the following year.

The color of the bark is a symptom which, though perhaps not always reliable, is among the first to develop. Instead of retaining the natural, reddish hue which all healthy trees possess until well advanced in years, the bark turns dark and has the external appearance of drying up. This I have found true in so large a number of cases, that I am satisfied it is an important aid to a complete and correct diagnosis. It should not be relied upon wholly, for other things than the yellows may produce the same effect, but it is at least indicative. During the last winter, several trees were diagnosed by the bark and wood alone—externally—and, in the majority of cases, subsequent examination confirmed the previous conclusions.

As the tree becomes more involved in a diseased condition, the foliage begins to show indications of the fact. The normal size of a peach leaf is from six to seven inches in length (Plate 3, fig. 1). The color is a rich leaf green. The outline is wavy, but the surface is uniform and not depressed by irregular curlings. As a tree

enters a diseased condition, the leaf decreases in size, the chlorophyll undergoes modification or is not perfectly formed, an abnormal green, red and yellow is developed (Plate 3, figs. 2 and 4) and these features continue to increase until the extremes are as represented in figs. 2 and 4—these being common examples of what may be found on any well-diseased tree. At times trees not involved in the yellows will exhibit leaves similar to that in Plate 2, fig. 4. This is a full-sized representation of a leaf suffering with the curl. This disease is entirely distinct from the yellows. The leaves show disorder with the very first growth of spring. As the fungus causing the disorder matures, the leaves become more and more curled and finally fall off during the month of June. Just previous to this a new set of leaves is started by the tree, and upon them, as they completely replace the first crop, almost the entire wood growth of the season is dependent. The second leaves rarely show any evidence of disease unless the tree is actually involved in the yellows, but generally present a fine appearance. Though distinct from the yellows, yet I feel satisfied there is a connection which should be carefully considered. I have noticed numbers of trees which were in all stages of infection with curl. Many, after developing the second set of leaves, have been thought to be otherwise healthy until later in the season, the color of the foliage pointed unmistakably to the first form of the yellows. The facts so far observed seem to show that the appearance of the curl is the first indication of a weakened vital energy, which will lead to the yellows if not immediately taken in hand. Trees which appear healthy early in the season will often manifest some sign of disease in the premature ripening of the foliage.

The last external characteristic of the disease, is to be found in the abnormal development of the wood. The branches of new growth become more and more depauperate as the disease advances, until finally they partake of a wiry character, and develop upon the main trunk and branches in lateral clusters as shown in the accompanying figure. This is a certain sign of an advanced stage of the yellows, but it comes so late in the course of development, that it may be dispensed with in a diagnosis which shall correctly determine the disease. The roots are invariably found to be healthy.

FUNGI.

The parasitic forms thus far observed are comprised by *Exoascus deformans* Fuckel, (*Ascomyces deformans* Berk, *Taphrina deformans*, Tul.), *Bispora monilioides* Cd., and *Pleospora herbarum* Rabh.,* (*Cladosporium herbarum*, Link.). Later examinations have shown no other well-defined forms of fungi to be present, and it is tolerably certain that these are all that accompany the disease of yellows. *Exoascus* is the fungus as already shown, through the action of which the disease commonly called curl is produced in the leaves. Its relatives are to be found on the plum, alder, thorn, hornbeam, and poplar,† while its own ravages extend to the peach, almond and cherry.

The effect of its growth is largely confined to and most conspicuous in the leaves, its mycelium penetrating their cellular structure and woody tissue in all directions.‡ Some of its relatives (*Exoascus carpini*, Erik.) even produce their worst

* Trans. Mass. Hort. Soc., Part I, 1882.

† Hartig. Baumkrankheiten, p. 116.

‡ Frank. Krankheiten der Pflanzen, p. 526.

effects upon the young branches, in the tender bark of which they fruit.* *Bispora* is regarded as a harmless individual, which accompanies many of the more or less destructive fungi, and it is to be found wherever there is decay of vegetable matter, being very common on dead stumps.

Pleospora is the only other parasite we have to consider. It is one of the most common on recently killed herbaceous and gramineous plants, though it occasionally appears upon living forms, and then becomes noxious. Thus, while it is in some cases a true parasite, it is chiefly to be regarded as a saprophyte which exerts little injury upon living matter.† This view seems to find support in our own observations, which show that the fungus occurred chiefly where there was either dead matter or a very low vitality, and that it cannot exert a very destructive influence, is fully demonstrated by the fact that it has been repeatedly seen on trees which were diseased but had been restored to a very healthy condition.‡

As *Exoascus* is not a necessary or constant feature of the yellows,§ *Pleospora* becomes the only parasite which can in any way be responsible for the disease, and a special consideration of the probabilities in this direction, will receive attention in the following pages.

DISCUSSION.

In order to give a clear exposition of the principles upon which the foregoing facts and statements are based, and logically discuss the correctness and error of the views presented that we may reach conclusions of value, it seems desirable to briefly review the definitions according to which a plant may be regarded as healthy or diseased.

It is not infrequently maintained that there is no such thing as a healthy organism. If we are to regard highly organized plants as individuals, and not as groups of individuals each whose functional activity is in a measure independent of its associates, this may be considered in a measure true, yet it would seem that where slight local disturbances may occur and not involve an impediment to the normal functions of the species as a whole, this view is a little too sweeping. It is rather better to adopt the definition of Frank,|| according to which he considers "disease every deviation from the normal condition of the species." Sorauer gives a very similar definition when he says, "We must recognize as a disease every disturbance of the organism which detracts from the final end of its labor, the accomplishment of its purpose."¶ There may be a predisposition to disease even in the normal state of an organism, but here the vital equilibrium is so nicely adjusted that when a second controlling factor is introduced, disease manifests itself. According to these views, therefore, it is not difficult to see that, though a complication of causes may operate to produce disease, it may be dependent upon one cause alone, and that may be the growth of other plants, an excess of certain food elements in the soil, an impoverishment of soil in certain directions, undue moisture, mechanical condition of the soil, the injuries inflicted by insects, animals or man, either by

* Hartig. Baumkrankheiten, p. 117.

† Krankheiten der Pflanzen, p. 580.

‡ Trans. Mass. Hort. Soc., Part I, 1882.

§ Trans. Mass. Hort. Soc., Part I, 1882.

|| Krankheiten der Pflanzen, p. 2.

¶ Handbuch, p. 56.

accident or design, and a great variety of meteorological conditions over which man has no control. To present these various facts in their true light, and be able to draw our conclusions in a clear manner, we will adopt the admirable classification of Hartig,* according to which he distributes the disturbing causes as follows :

1. Phenogamic plants.
2. Cryptogamic plants.
3. Injuries.
4. Soil influences.
5. Atmospheric influences.

The first class includes such diseases as are produced by phenogamic parasites like the mistletoe and dodder. As no cause of this kind appears in the disease under consideration, the first group must be excluded from the present discussion. The second class embraces all such diseases as are in any way due to the growth of parasitic fungi, hence must receive further consideration. The third class also demands notice, as it embraces insect agency. The fourth and fifth classes also deserve important consideration.

CRYPTOGAMIC PLANTS.

While it is well recognized that the growth of cryptogamic parasites upon other vegetable organisms generally accompanies disease, it is not clearly defined how far we are to regard these growths as the actual cause of the disorder of which they are concomitants, and it becomes imperative to distinguish, as far as we can, between the fungus as a possible cause, and its presence as a secondary feature of the already disordered organic functions. The growth of one organism upon another is at best but a struggle for supremacy, which must be conceded in favor of that individual which is capable of bringing the greatest vital resources to bear upon its antagonist for the longest time. While it is accepted by many that bacteria and similar organisms are actually capable of inducing disease, it is certain that many parasites are only concomitants of a pathological condition. Their action is of varying degrees of strength, and it becomes a question as to how far the action of even the worst can be controlled. If, by proper aid, the host gains in vital energy over its parasite, then the conditions are most favorable for its final supremacy, and there is a strong and growing tendency among physiologists to regard the destructive action of these low organisms as within control when the vigor of the host is properly secured and maintained. The fungi accompanying the yellows have been shown to enter the tree and exert their greatest influence only when the conditions become favorable through injury or predisposition,† and the fact that these organisms are found, not only upon diseased trees, *but also upon trees which have been restored by a rational course of treatment*, shows that in this case at least, the action of the parasite *can* be controlled.

The cancer of the apple tree is believed to operate most readily and generally through previous injury to the tree.‡ The *Nectria*, which so commonly attacks the fir trees of Bavaria, gains its firmest hold through injuries inflicted by snow and hail.§ All these facts point directly to the belief that a low vitality is the chief cause which enables parasites to exert their destructive influence, that so far they are incidental to,

* Baumkrankheiten, p. 6.

† Trans. Mass. Hort. Soc., Part I, 1882.

‡ Monatschr. Deutscher Garten, 1880; Bot. Zeit. XXXIX, 1881, and Unters. fürstbot. Inst. München 1, 1880.

§ Unters. fürstbot. Inst. München, 1880.

or only the secondary causes of disease. One more fact not yet on record points strongly in the direction just indicated. In the year of our Centennial, one of the French Commissioners visited the vineyards at Amherst, Mass., then under a course of experimental treatment with special fertilizers by Dr. Goessmann. The Commissioner remarked that he had nowhere seen more vigorous vines and better development of fruit, but at the same time called attention to the fact that the vines were loaded with Phylloxera, and expressed surprise that such should be the case. The Doctor touched the keynote of the whole question when he replied, "We feed the vines and the Phylloxera too."

We have already seen that there is but one fungus which can be considered as exerting any deleterious influence in the yellows. Our examination of the character of the parasite, however, makes it clear that its habits are such as to render its action in a highly-vitalized organism of little consequence, and that it is easily eradicated. We are therefore led to conclude that it is not the cause of the yellows, but that it is only an incidental feature of the disease. As such, however, and capable of producing secondary effects, it should not be neglected.

Fungi in general flourish best under conditions of great heat and moisture, and, as these conditions are beyond our control, we can only adopt the best means possible for maintaining the normal vigor of the plant to such an extent that it may be capable of resisting the influences of its environment. Compounds which are destructive to vegetable life may be applied for the destruction of the fungus, and this has been the basis for the treatment of such diseases in almost every case in the past. But we must carefully bear in mind that, as the value of the remedy consists in its ability to destroy life, it not only destroys the parasite but exerts a positive injury upon the host, and thereby the latter is rendered even more subject to disease than before. If we can apply that which will be destructive to the fungus, and at the same time provide nourishment for the host, our purpose will be best accomplished.

INJURIES.

Plants are at all times liable to injuries which may be the result of accident or design. In any case, an injury necessarily reduces the vital energy of the part acted upon, and through this the vitality of the entire organism is affected. The way is thus opened for the introduction of disease into the general system. According to the extent of the injury and the consequent exhaustion of the vital resources, the disease may be strictly localized, or it may become common to the whole system. The most frequent form of disease, resulting from injury, is that developed through the subsequent action of fungi.*

The only form of injury which has been noticed in connection with the yellows, or, at least, which seems to have any connection with it, is that produced by insect agency. The common peach borer, *Ageria exitiosa* Say, is known to frequently attack the tree near its roots, and to such an extent does its ravages interfere with the normal functions, that death will ensue if the disturbing cause be not removed. The symptoms displayed are in some respects like those of the yellows. The leaves turn yellow, and fall prematurely. It is not difficult for a careful observer to make a proper distinction, however, and what this is will appear in the diagnosis to follow. There is no direct connection between the borer and the yellows beyond the fact that

* Monatss. Deutscher Garten. 1880. Unters fürshot. Inst., München, 1880.

the action of the former may serve as a predisposing cause; but the yellows may, and very frequently do, develop where the borer has never acted.

A second possibility is met in the action of another borer—*Scolytus rugulosus*, Ratzburg—which perforates the tender bark of both trunk and branches. Several trees in this vicinity have suffered severely during the past year from the ravages of this insect. So far as our observations have been carried, the beetle may perforate thick bark, but the larvæ cannot be found in such. There is simply a perforation directly inward as far as the wood, but no lateral ramifications. In the thinner and more tender bark of the younger trees, the first punctures will be found to lead into lateral channels which run in all directions. In these the larvæ will be found abundantly at any time during the winter. The action of the insect and its larvæ causes the bark to be thrown up into slightly projecting warts which increase in size as the action of the insect continues. The entire bark finally turns black, a sure indication that it is dead and that the tree cannot live long. The destruction is most complete, since the ravages of the burrowing larvæ are confined to the cambium region, the soft, young growth of which is completely destroyed. All the cases brought to my notice have shown the borer to be acting upon diseased trees. In a communication from Prof. Riley, he says, that “so far as known, this borer and other species of *Scolytidae* usually attack only those trees which have suffered from frost or disease, *i. e.*, they oviposit only in such trees; but, for feeding purposes, they also attack healthy trees. While this beetle is now known from Virginia to New York, it is believed to be a recent importation from Europe, since its earliest notice in this country was in 1877. The most effective mode of dealing with it is to destroy the tree before spring opens.” It is important that this destroyer should be carefully looked after, and its progress through the country noted. The facts here stated show that however much damage this *Scolytus* may do to peach trees, we cannot regard it as in any way connected with the yellows; it cannot be considered as a predisposing cause even. We are therefore justified in the belief that the yellows is not to find a sufficient cause in injuries, but that it arises from independent causes.

SOIL INFLUENCES.

The mechanical condition of the soil exerts a marked influence upon whatever may grow upon it, for upon this condition depends the relation of supply to demand, and the exercise of those peculiar physical properties which render special soils adapted to the cultivation of particular kinds of plants. In the cultivation of the peach, this is not less true than in the case of other crops, and evidence of this fact is to be found in the benefit which some of our orchardists testify is to be derived by the diseased tree when proper cultivation is given it. Others claim that cultivation produces no effect, either for good or bad, while others even go to the extreme of a clear and explicit declaration that cultivation is positively injurious and productive of disorder.

Among these diverse views entertained by practical men, we have been able to ascertain from our own observations that, while an uncultivated soil and a neglected mechanical condition are, under some circumstances, favorable to disease, they cannot be considered as the cause of the affection now under discussion.

Want of proper drainage, and stagnation of water in the soil, are causes which may lead to disease. Wherever there is an undue accumulation of water, there is

liable to be a disturbance of the normal activity of the root functions, and when this occurs, the entire physiological activity of the plant is apt to meet with impediment.

The experiments of Sachs show that absorption of water through the roots is subject to certain limits of temperature.* In the case of tobacco and the gourd, it was found that the activity of the roots was so far impaired, that they were unable to supply the demands created by even a small loss by transpiration when the temperature of the moist soil was depressed to 3 or 5 degrees centigrade. When the temperature was raised to 12 or 18 degrees, the functions of the root were restored to their normal degree of activity. Different plants require different temperatures for the maintenance of the root functions, and these conditions are secured to them by the laws governing their natural distribution and location on different soils and in different localities. The experimental production of abnormal conditions is but an artificial development of what may be produced in the soil under the influence of peculiar meteorological conditions. A heavy rainfall causes a marked effect upon and depression of the soil temperature†, and if this depression continue beyond a certain time, either through natural conditions or through want of proper drainage, which could be readily secured, damage is liable to result. It will be found, however, as my experience shows, that peaches are not cultivated where such stagnation is likely to occur. On the other hand, the disease appears abundantly on slopes and hills where the drainage is good. No possible cause appears in this, therefore.

Fermentable, heat-producing manures are always productive of more or less rank growth in plants on account of their stimulating qualities. Such stimulation, when carried beyond certain limits, is in turn productive of weakness, and thus the way is opened for the introduction of disease through secondary influences. Again, such manures possess the most favorable conditions for the growth of fungi, and always invite the development of these organisms upon themselves. In this way they operate to introduce the secondary cause of disease, of the first of which they constitute the prime factor. The testimony of practical men, as well as my own observations, show that the disease called yellows appears on land which is not cultivated, and to which no stable manure has been applied. A justifiable cause of the disease is not to be found in this, therefore.

A low vitality may result from want of proper nourishment, and this is so true, that we may readily bring about an exhausted condition of the plant by artificial means,‡ and this will be in all essential respects the same as that produced when the soil becomes exhausted and fails to supply the proper amount of food to the plant. It is very generally urged by horticulturists at the present time, that the yellows cannot be produced in this way, and support their arguments by reference to the crops of other kinds which flourish and yield abundantly by the side of the diseased trees. To all such we would say, there is a vast and important difference between general exhaustion of the soil, by which it becomes incapable of producing any kind of a crop in a normal degree of strength, and special exhaustion, when the soil possesses the ability to supply the requirements of certain plants, but is utterly unable to meet the requirements of other plants in some particular element of food essential to their perfect growth and maturity. It is upon this law of special exhaustion that the entire principle of rotation in crops is based. While the land is feeding one class of

* Sachs Text-Book of Botany, p. 652.

† H. F. Series I, No. 2.

‡ Nobbe, Schroeder and Erdmann, Chemnitz, 1871, and Leydhecker, Versuchs-stat. VIII.

plants, it is accumulating food not specially demanded by them, but which will be of the greatest importance to those of another class. The fact already cited, that trees have been grown upon land where diseased orchards formerly stood, after a period of rest, and that after a time of second cultivation the yellows again appeared and necessitated abandonment of the culture, points directly to special exhaustion of the soil. The facts obtained by chemical analysis as previously given, show the want of certain food elements, and further shows that these elements stand in direct relation to the pathological condition, being more abundant in the healthy than in the diseased. There is also a direct relation between the supply of these food elements and the storage of reserve material in various parts of the plant,* as peculiar to the yellows, and as already shown, this same relation is found to hold true and to be developed under conditions of artificial cultivation when certain elements of food are withheld. Last of all, we may add that one of the best evidences of special exhaustion is to be found in the actual cures effected by the application of those elements supposed to be wanting, to the diseased tree.

It is therefore fairly certain, that in the soil we have one of the most, if not *the* most important influence productive of the yellows.

ATMOSPHERIC INFLUENCES.

Excess of moisture and heat in combination, are the most favorable conditions for the development of all kinds of fungi. Instances of this are never wanting, and might be cited almost without end. These conditions being meteorological, are beyond our control, and subject to periodicity of recurrence. There is, therefore, so far as these conditions control their growth, a liability to corresponding periodicity in the growth of fungi and development of the diseases of which they are supposed to be productive. The same stimulation is exerted upon the plants themselves, and thereby a tendency to weakened vitality is induced, which will allow parasites to gain a firmer hold. There are no facts on hand, however, which will warrant us in assigning this as the cause of the yellows.

Drought induces an impediment of the vital functions by causing excessive transpiration from the leaves and subsequent stagnation of the entire circulation. This has a conspicuous illustration in the tomato rot, which prevailed so extensively last summer. It was observed to reach its greatest development during the driest part of the season. It involved the extremities and fruit first, and rapidly disappeared with the advent of rains. During the early development of the rot on the fruit, no fungus growth was to be seen, and not until an advanced stage of the disease did this make its appearance. Then *Fusisporium solani* Mart. was found in abundance. There was no special evidence, however, that trees had suffered beyond their ability to recover, and no reason has yet been presented for entertaining the belief that the yellows could have its origin in this cause. On the other hand, the usual appearance of the disease after the trees have produced fruit, and its development on young trees in the early growth of spring, point directly, rather to want of proper food than to these causes.

Injury may be inflicted by the action of frost and winter killing of portions of the tree. In this way a reduced vitality may be produced, but the general testimony seems to show that the active cause of the trouble is not to be found here.

* Trans. Mass. Hort. Soc. 1882.

In reviewing these various considerations, the conviction becomes more firmly impressed upon us that, while the growth of parasites, the operation of insects, and the effect of atmospheric conditions may, and undoubtedly do, exert an important influence in the production of disease, the yellows cannot be ascribed primarily to these causes, but finds its origin in conditions of special soil exhaustion, and that a rational course of treatment will be directed towards supplying the wants here manifested.

DIAGNOSIS.

It is essential that we should here present a correct and complete diagnosis of the disease as it now appears, and indicate those features which are to be considered of the greatest importance in detecting the disorder in its early stages. It is desirable once more, to point out the necessity of a careful distinction, between peach yellows and peach blight.

1. An excess of lime, and a want of potash in wood and fruit.
2. Deficiency of chlorine.
3. Abnormal and loose cellular structure in the bark ; the formation of wood abnormally dense, and the cells small.
4. An excessive storage of carbohydrate, particularly in the cortical region.
5. The presence of calcium oxalate in large quantities.
6. The fruit ripens prematurely, develops an unnatural color and flavor, becomes abnormally velvety, and often persists more than a year.
7. The leaves lose their normal color and become yellow and red, show perforations and dark patches and are often reduced in size to one inch in length.
8. The new growth is depauperate ; the young twigs form in lateral clusters of wiry shoots upon the main branches, and partake of a more or less brilliant yellow and red color.
9. The bark of the main trunk and branches becomes dark and parched.
10. The disease first appears on the young branches and gradually involves the entire tree.
11. The disease is not developed suddenly, but appears gradually ; nor is it localized in its action to particular parts of the tree.
12. The roots are always healthy.

The most important elements of the diagnosis for the detection of the disease in its early stages, are those included in sections 3, 4 and 6. By the first two the disease may be detected with certainty when no fruit has yet appeared. The other elements of the diagnosis are of varying importance. It only remains for us to point out the course of treatment which the facts here stated indicate to be effective.

1. Avoid the undue application of stable manures. If necessary to use them, have them well composted.
2. If the tree is already badly diseased, trim back all the branches showing wiry twigs, the object being to remove as much of the diseased structure as possible without killing the tree.
3. Cultivate the tree as you would any other crop that requires careful attention, and from which you expect to get paying returns.
4. Apply commercial fertilizers of the following mixture :—

Kieserite	25 pounds.
Muriate of potash	100 to 150 pounds.
Dissolved bone black	450 lbs.

This is the proper quantity for an acre, which, allowing 70 to 100 trees to the acre, will give about 6 to 9 pounds to the tree. This will furnish a complete manure, and ensure a general building up of the entire system.

If the trees are in an advanced stage of the disease, add more muriate of potash, giving about four pounds of this salt to a tree of average size and age. Apply in the spring before growth commences, and repeat in the fall.

To apply the fertilizers, spade the ground as far as the roots extend. Mulch with the inverted sods or with straw, and apply the fertilizer to this, leaving a space of one foot all about the tree. The object of the mulch is to prevent too sudden contact with the roots. If this occurs the strong fertilizers will be apt to cause injury.

In conclusion we may add that the arguments as presented seem to justify the belief that a correct diagnosis and remedy have been developed, and that it only remains to demonstrate by careful trial through a series of years, the value of the remedy and the special methods of its successful application under the varying conditions of soil and climate in widely separated localities.

TABLE OF COMPARATIVE TEMPERATURES.
Centigrade to Fahrenheit.

° CENT.	° FAHR.	° CENT.	° FAHR.	° CENT.	° FAHR.
100.00	212.00	58.00	136.40	16.00	60.80
99.00	210.20	57.00	134.60	15.00	59.00
98.00	208.40	56.00	132.80	14.00	57.20
97.00	206.60	55.00	131.00	13.00	55.40
96.00	204.80	54.00	129.20	12.00	53.60
95.00	203.00	53.00	127.40	11.00	51.80
94.00	201.20	52.00	125.60	10.00	50.00
93.00	199.40	51.00	123.80	9.00	48.20
92.00	197.60	50.00	122.00	8.00	46.40
91.00	195.80	49.00	120.20	7.00	44.60
90.00	194.00	48.00	118.40	6.00	42.80
89.00	192.20	47.00	116.60	5.00	41.00
88.00	190.40	46.00	114.80	4.00	39.20
87.00	188.60	45.00	113.00	3.00	37.40
86.00	186.80	44.00	111.20	2.00	35.60
85.00	185.00	43.00	109.40	1.00	33.80
84.00	183.20	42.00	107.60	0.00	32.00
83.00	181.40	41.00	105.80	— 1.00	30.20
82.00	179.60	40.00	104.00	— 2.00	28.40
81.00	177.80	39.00	102.20	— 3.00	26.60
80.00	176.00	38.00	100.40	— 4.00	24.80
79.00	174.20	37.00	98.60	— 5.00	23.00
78.00	172.40	36.00	96.80	— 6.00	21.20
77.00	170.60	35.00	95.00	— 7.00	19.40
76.00	168.80	34.00	93.20	— 8.00	17.60
75.00	167.00	33.00	91.40	— 9.00	15.80
74.00	165.20	32.00	89.60	— 10.00	14.00
73.00	163.40	31.00	87.80	— 11.00	12.20
72.00	161.60	30.00	86.00	— 12.00	10.40
71.00	159.80	29.00	84.20	— 13.00	8.60
70.00	158.00	28.00	82.40	— 14.00	6.80
69.00	156.20	27.00	80.60	— 15.00	5.00
68.00	154.40	26.00	78.80	— 16.00	3.20
67.00	152.60	25.00	77.00	— 17.00	1.40
66.00	150.80	24.00	75.20	— 18.00	— 0.40
65.00	149.00	23.00	73.40	— 19.00	— 2.20
64.00	147.20	22.00	71.60	— 20.00	— 4.00
63.00	145.40	21.00	69.80		
62.00	143.60	20.00	68.00		
61.00	141.80	19.00	66.20		
60.00	140.00	18.00	64.40		
59.00	138.20	17.00	62.60		

THERMOMETRIC RATIOS.

Reaumur..... 4°

Centigrade..... 5°

Fahrenheit... 9°

4 : 5 :: deg. R. : deg. C.

5 : 9 :: deg. C. : Deg. F. + 32.

Converting to degrees Fahrenheit, add 32 degrees.

Converting to degrees Centigrade or Reaumur, subtract 32 degrees Fahrenheit before performing the operation.

EXPLANATION OF THE PLATES.

PLATE I.

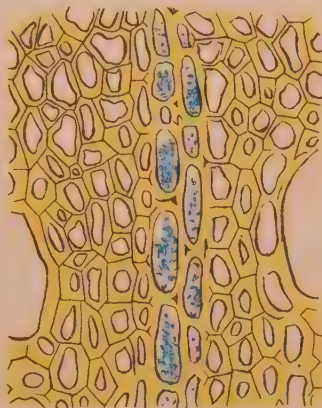
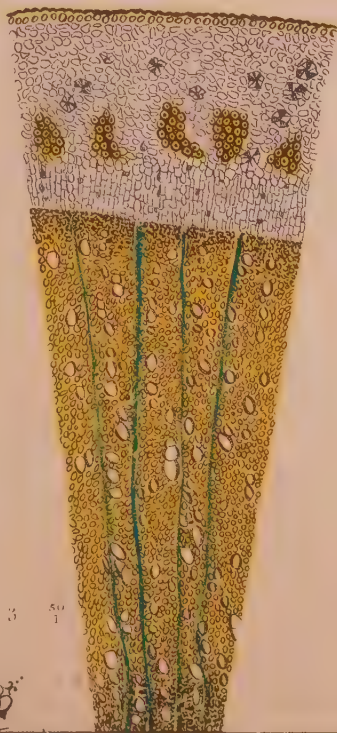
- Fig. 1.*—Complete section of stem from a tree never diseased.
Fig. 2.—Section of bark from the same, more highly magnified.
Fig. 3.—Complete section of stem from tree once diseased, but restored.
Fig. 4.—Section of bark from the same, more highly magnified.
Fig. 5.—Section of healthy wood, highly magnified.

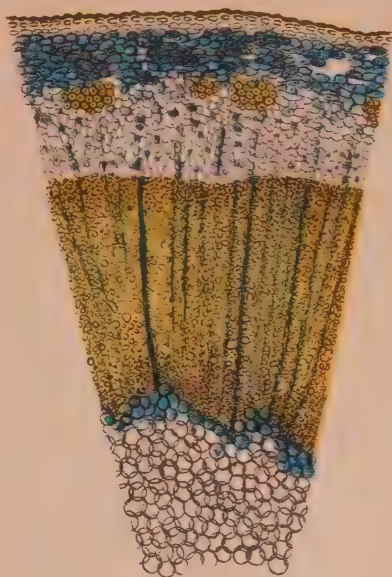
PLATE II.

- Fig. 1.*—Complete section of stem from diseased tree.
Fig. 2.—Section of bark from the same, highly magnified.
Fig. 3.—Section of diseased wood.

PLATE III.

- Fig 1.*—Healthy leaf of full size.
Figs. 2, 3 & 4.—Leaves of natural size, showing their appearance in different stages of the disease.

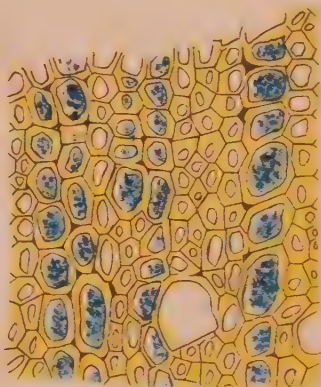




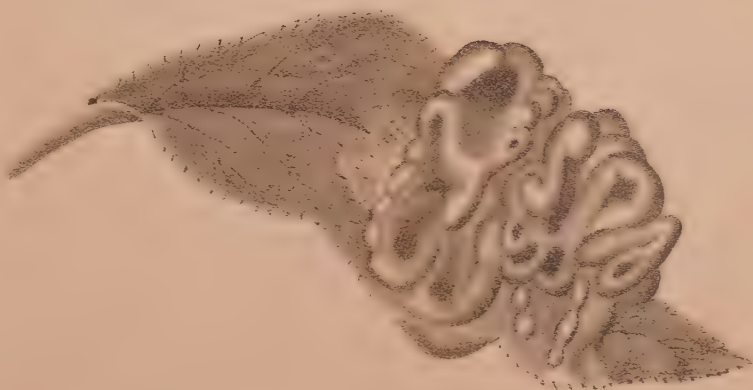
1 - 5v



2 - 5v



3 - 5v





PEACH YELLOWS
1882



Julius Bernhart

PEACH YELLOWS
DISEASED TREES, FROM A PHOTOGRAPH
1882.



